

National Standard of the People's Republic of China

# High strength low alloy structural steels

GB/T 1591-1994

This standard refers to ISO 4950:1981 < High yield strength flat steel products > and ISO 4951:1979 < High yield strength steel bars and sections >.

## 1. Subject and Scope

This standard specifies steel grade, technical requirement, test method, inspection rule, packaging, marking and quality certificate of high strength low alloy structural steels, etc.

This national standard is applicable to hot rolled, controlling rolled, normalizing, normalizing plus tempering conditions steels for engineering purposes and normal structure steel for plates, strips with thickness not less than 3mm, sectional steels and bars, normally to be used in supplied conditions.

The chemical composition of high strength low alloy structural steels in this standard is also applicable to steel ingot, continuous casting blank, steel blank and its products.

## 2. Referenced Documents

GB/T 222-1984 Method of sampling steel for determination of chemical composition and permissible variations for product analysis

GB/T 223 Methods for chemical analysis of iron, steel and alloy

GB/T 228-1987 Metallic materials--Tensile testing

GB/T 232-1988 Metallic materials--Bend test

GB/T 247-1997 General requirements of acceptance, packaging, marking and certification for steel plates (sheets) and strips

GB/T 2101-1989 General requirements of acceptance, packaging, marking and certification for section steel

GB/T 2106 Metallic materials—Charpy notch (V notch ) impact test

GB/T 2975 Steel and steel products—location and preparation of test pieces for mechanical testing

GB/T 4159 Metallic materials—low temperature Charpy notch impact test

GB/T 6397-1986 Metallic materials--Test pieces for tensile testing

GB/T 13304-1991 Steels—Classification

## 3. Steel Grade Nomenclature

There are three parts for Steel grade lining up as Q (means Yield Point), value of yield point, and symbol of quality level (grade A, B, C, D and E).

For example: Q390A

Where:

Q: means Yield Point,

390: means value of Yield Point, MPa,

A, B, C, D, E: means different level for quality

#### 4. Requirements of Size, Shape, Weight, etc

Size, shape, weight and permissible variations shall conform to relevant standards.

#### 5. Technical Requirements

##### 5.1 Steel Grade and Chemical Composition

5.1.1 Steel grade and chemical composition (heat analysis) shall conform to table 1, alloy elements composition shall be conform to the low alloy steel specified in GB/T 13304.

Table 1:

Steel Grade	Quality Grade	Chemical composition, %										
		C $\leq$	Mn	Si $\leq$	P $\leq$	S $\leq$	V	Nb	Ti	Al $\geq$	Cr $\leq$	Ni $\leq$
Q295	A	0.16	0.8-1.50	0.55	0.045	0.045	0.02-0.15	0.015-0.060	0.02-0.20	-	-	-
	B	0.16	0.8-1.50	0.55	0.040	0.040	0.02-0.15	0.015-0.060	0.02-0.20	-	-	-
Q345	A	0.20	1.0~1.60	0.55	0.045	0.045	0.02-0.15	0.015-0.060	0.02-0.20	-	-	-
	B	0.20	1.0~1.60	0.55	0.040	0.040	0.02-0.15	0.015-0.060	0.02-0.20	-	-	-
	C	0.20	1.0~1.60	0.55	0.035	0.035	0.02-0.15	0.015-0.060	0.02-0.20	0.015	-	-
	D	0.18	1.0~1.60	0.55	0.030	0.030	0.02-0.15	0.015-0.060	0.02-0.20	0.015	-	-
	E	0.18	1.0~1.60	0.55	0.025	0.025	0.02-0.15	0.015-0.060	0.02-0.20	0.015	-	-
Q390	A	0.20	1.0~1.60	0.55	0.045	0.045	0.02-0.20	0.015-0.060	0.02-0.20	-	0.30	0.70
	B	0.20	1.0~1.60	0.55	0.040	0.040	0.02-0.20	0.015-0.060	0.02-0.20	-	0.30	0.70
	C	0.20	1.0~1.60	0.55	0.035	0.035	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.30	0.70
	D	0.20	1.0~1.60	0.55	0.030	0.030	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.30	0.70
	E	0.20	1.0~1.60	0.55	0.025	0.025	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.30	0.70
Q420	A	0.20	1.0~1.70	0.55	0.045	0.045	0.02-0.20	0.015-0.060	0.02-0.20	-	0.40	0.70
	B	0.20	1.0~1.70	0.55	0.040	0.040	0.02-0.20	0.015-0.060	0.02-0.20	-	0.40	0.70
	C	0.20	1.0~1.70	0.55	0.035	0.035	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.40	0.70
	D	0.20	1.0~1.70	0.55	0.030	0.030	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.40	0.70
	E	0.20	1.0~1.70	0.55	0.025	0.025	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.40	0.70
Q460	C	0.20	1.0~1.70	0.55	0.035	0.035	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.70	0.70
	D	0.20	1.0~1.70	0.55	0.030	0.030	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.70	0.70
	E	0.20	1.0~1.70	0.55	0.025	0.025	0.02-0.20	0.015-0.060	0.02-0.20	0.015	0.70	0.70

NOTES: Al content in this table is complete Al, if acid soluble aluminum is analyzed, the content shall be not less than 0.010%.

- 5.1.1.1 0.18% Carbon content in Q295 also could be delivered.
- 5.1.1.2 For Q295 without V, Nb, Ti, when  $C \leq 0.12\%$ , upper limited of Mn content could be up to 1.80%.
- 5.1.1.3 For Q235, upper limited of Mn content could be up to 1.70%.
- 5.1.1.4 Plate and strips thickness  $\leq 6\text{mm}$ , hot continuous casting plate and strip thickness  $\leq 16\text{mm}$ , low limited of Mn content could be up to 0.20%.
- 5.1.1.5 Being ensured that mechanical property conforms to this standard, and when Nb is added as refining grain element, low limit of Mn content in Q345, Q390 could be lower than low limit in table 1.
- 5.1.1.6 Except grade A and B steel, one of refining grain elements (V, Nb, Ti, Al) in table 1 shall be added. If many of them are added, one of added element shall not be less than specified minimum value.
- 5.1.1.7 In order to improve performance of steel, grade A and B steel also could be added refining grain elements V or Nb or Ti, etc and its content shall conform to table 1. If it isn't added as alloy element, the lowest content isn't limited.
- 5.1.1.8 When refining grain elements are not added to steel, it needn't analysis, and warrantee is invalid, too.
- 5.1.1.9 For sectional steel and bar, the low limit content of Nb is 0.005%.
- 5.1.1.10 Each Content of Residual elements Cr, Ni, Cu shall not exceed 0.30%, and don't need to be analyzed if supplier could guarantee.
- 5.1.1.11 In order to improve performance of steel, a little Mo could be added in Q390, Q420, Q460 steel.
- 5.1.1.12 In order to improve performance of steel, RE element could be added in all grade steel, the content shall be 0.02%~0.20%.
- 5.1.1.13 Through negotiation by and between both sides, N element could be added in Q420, heat analysis result shall be 0.010%~0.020%.
- 5.1.2 When steel ingot, continuous casting blank, steel blank are supplied, the low limit content of C, Si elements could be specified by customer to guarantee the mechanic property in this standard..
- 5.1.3 The permissible variation of Chemical composition for steel ingot, continuous casting blank, steel blank shall conform to GB 222.

## 5.2 Smelt method

Steel could be made by oxygen converter, open hearth or electric furnace. Supplier will select smelt method unless customer have special requirements.

## 5.3 Delivery Conditions

5.3.1 Steel shall be delivered in conditions of hot rolled, controlling rolled, normalizing, normalizing plus tempering conditions. Grade C, D, E of Q420, Q460 also could be delivered in conditions of quenching plus tempering.

5.3.2 Delivery conditions shall be indicated in contract, otherwise supplier shall decided it.

#### 5.4 Mechanical Property and Process Performance

5.4.1 Result of tensile test, impact test and bend test shall be conform to table 2.

Table2:

Steel  Grade	Quality	Yield point, $\sigma_s$ , MPa				Tensile	Elong- ation  $\delta_s$ , %	Impact work, AkV,				180° bend test,	
	Grade	Thickness (diameter, edge), mm				Strength  $\sigma_b$  MPa		Longitudinal, J					
		$\leq$	$>$	$>$	$>$			+20	0	-20	-40		
		16	16-35	35-50	50-100			°C	°C	°C	°C	Thickness (diameter),mm	
Not less than						Not less than						$\leq 16$	$> 16-100$
Q295	A	295	275	255	235	390-570	23					d=2a	d=3a
	B	295	275	255	235	390-570	23	34				d=2a	d=3a
Q345	A	345	325	295	275	470-630	21					d=2a	d=3a
	B	345	325	295	275	470-630	21	34				d=2a	d=3a
	C	345	325	295	275	470-630	22		34			d=2a	d=3a
	D	345	325	295	275	470-630	22			34		d=2a	d=3a
	E	345	325	295	275	470-630	22				27	d=2a	d=3a
Q390	A	390	370	350	330	490-650	19					d=2a	d=3a
	B	390	370	350	330	490-650	19	34				d=2a	d=3a
	C	390	370	350	330	490-650	20		34			d=2a	d=3a
	D	390	370	350	330	490-650	20			34		d=2a	d=3a
	E	390	370	350	330	490-650	20				27	d=2a	d=3a
Q420	A	420	400	380	360	520-680	18					d=2a	d=3a
	B	420	400	380	360	520-680	18	34				d=2a	d=3a
	C	420	400	380	360	520-680	19		34			d=2a	d=3a
	D	420	400	380	360	520-680	19			34		d=2a	d=3a
	E	420	400	380	360	520-680	19				27	d=2a	d=3a
Q460	C	460	440	420	400	550-720	17		34			d=2a	d=3a

	D	460	440	420	400	550-720	17			34		d=2a	d=3a
	E	460	440	420	400	550-720	17				27	d=2a	d=3a
d: diameter of bend core; a: thickness of samples													

5.4.1.1 When tensile test and bend test are implemented, steel plates and strips shall take transverse samples, and steel strips less than 600mm width, sectional steels, bars shall take longitudinal samples.

5.4.1.2 Elongation percent of Steel plate and strips shall be permitted to be 1% lower than ones in table 2 (absolution value)

5.4.1.3 For steel plate thickness more than 35mm , percent of elongation shall be permitted to be 1% lower (absolution value).

5.4.1.4 For Square steel, round steel, edge or diameter is more than 50~100mm, percent of elongation shall be permitted to be 1% lower than ones in table 2 (absolution value).

5.4.1.5 The upper limit value of tensile strength for wide steel strips (coil) shall not be the conditions of delivery.

5.4.1.6 Grade A steel shall test bend property. Others steels could be free of testing if supplier could guarantee the result of bend test conform to table 2.

5.4.1.7 Impact work and test temperature of Charpy notch impact test (V notch) shall conform to table 2. Three samples will be one group, the mean arithmetic value of impact work of three samples shall be not less than 70% of prescribed value. One of them is permitted 30% lower than the minimum amounts prescribed in table 6.

5.4.1.8 When 5mm×10mm×55mm samples are tested as small specimen for impact, the result shall not be less than 50% of prescribed value.

5.4.2 Q460 and all grade D, E steels normally are not supplied as sectional steels and bars.

5.4.3 The property of other steels that are not listed in table 2 shall be decided through negotiation by and between both sides.

## 5.5 Surface Quality

Surface quality of steel shall conform to relevant standard.

## 6. Test Method

6.1 Test items, quality of samples, sampling position and test method of each lot shall conform to table 3.

Table 3:

No.	Item	Quantity, Piece	Sampling Method	Test Method
1	Chemical analysis	1 (per batch furnace number)	GB 222	GB 223
2	Tensile	1	GB 2975	GB 228

				GB 6397
3	Bend	1	GB 2975	GB 232
4	Normal temperature impact	3	GB 2975	GB 2106
5	Low temperature impact	3	GB 2975	GB 4159

6.2 Steel plates, steel strips and sectional steels thickness  $\geq 12\text{mm}$  or steel bar diameter  $\geq 16\text{mm}$ , impact test specimen shall be  $10\text{mm} \times 10\text{mm} \times 55\text{mm}$ ; steel plates, steel strips and sectional steels thickness  $6 \sim < 12\text{mm}$  or steel bar diameter  $6 \sim < 12\text{mm}$ , impact test specimen shall be  $5\text{mm} \times 10\text{mm} \times 55\text{mm}$ . Impact test sample could keep a rolled surface, and its longitudinal axis shall be paralleled with rolled direction.

6.3 The thickness or diameter of steel to be tested bend property is more than  $20\text{mm}$ , test specimen with one side planed and peeled shall be  $20\text{mm}$ , diameter of bend core shall conform to table 2. when specimen tested, the unmachined surface shall face to outside of bend. If test specimen is unmachined, diameter of bend core shall be added one test specimen thickness “a” specified in table 2.

## 7. Test Rule

### 7.1 examination and acceptance

Seller's technical supervisor department shall implement examination and acceptance

7.2 Steel shall be examined and accepted secundum lots. Steel of each lot shall be the same steel grade, same quality grade, same batch furnace number or same sort, same size, same heat treatment conditions (delivery in heat treatment conditions).

Grade A and B are permitted the same steel grade, same smelt and casting method, different batch furnace number to commix. But each lot shall not be more than six furnace numbers, and among furnace numbers the difference of C content shall be not more than  $0.02\%$ , the difference of Mn content shall be not more than  $0.15\%$ . Each lot steel shall be not less than  $60\text{t}$

7.3 When charpy notch impact test (V notch) result doesn't conform to the specification, more group three samples should be taken from the same lot for test, average value of total six samples shall be not less than specified value in table 2, two of them are permitted to be lower than specified value, but only one of them could be  $70\%$  lower than specified value.

7.4 Steel of retest and determine rule shall conform to GB247, GB2101.

## 8. Packing, Marking and Quality Certificate

The packing, marking and quality certificate shall be in accordance with GB247, GB2101.

## Appendix A

### Standard Steel Grade Comparison between New and Old Low Alloy Structural Steels standard (for reference)

A1 Steel Grade Comparison in GB/T 1591-94 and GB/T 1591-88 as follows:

GB/T 1591-94	GB/T 1591-88
Q295	09MnV, 09MnNb, 09Mn2, 12Mn
Q345	12MnV, 14MnNb, 16Mn, 16MnRE, 18Nb
Q390	15MnV, 15MnTi, 16MnNb,
Q420	15MnVN, 14MnVTiRE
Q460	